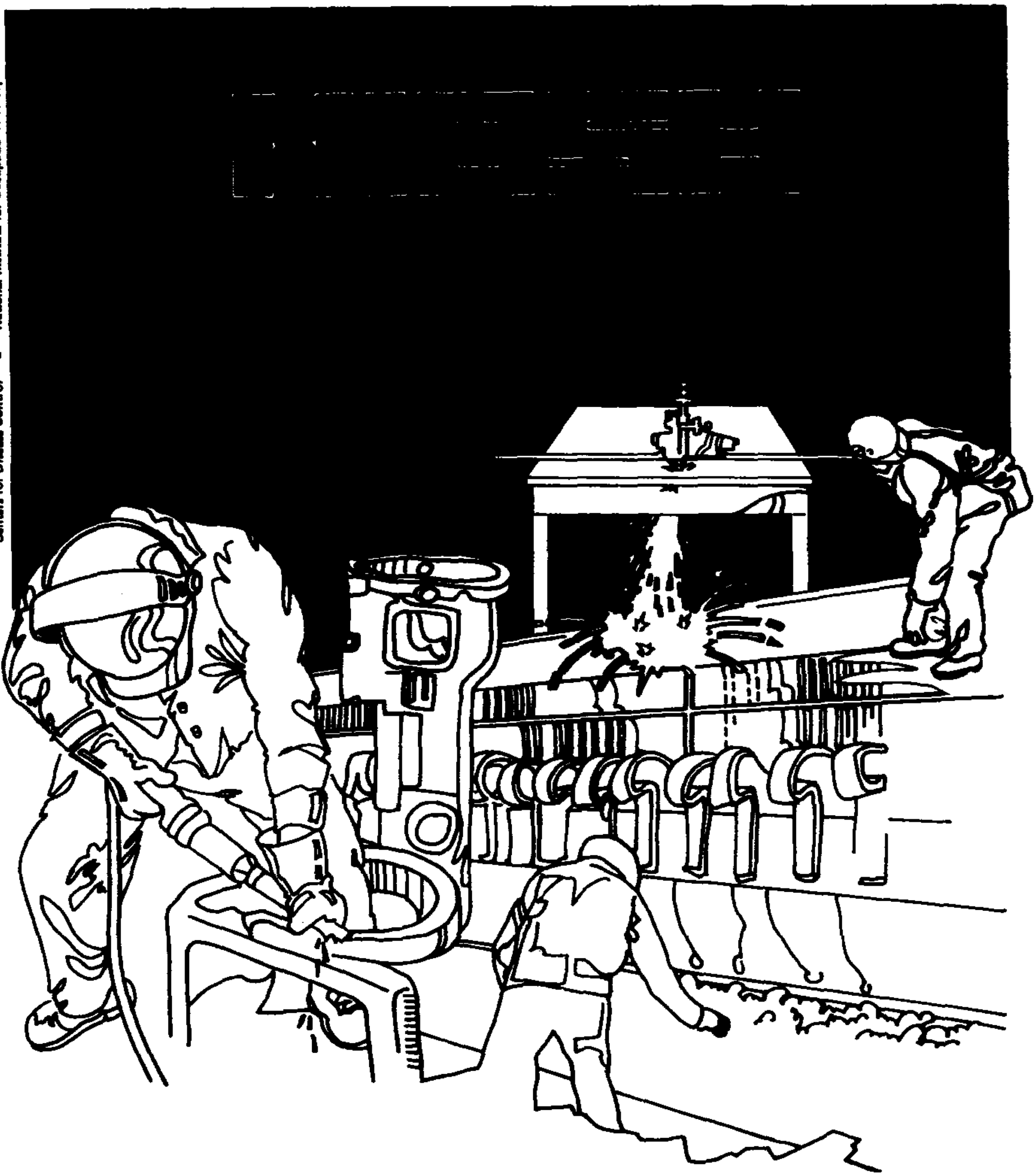
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 87-321-1880
BARMET ALUMINUM CORPORATION
LIVERMORE, KENTUCKY

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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BARMET ALUMINUM CORPORATION
LIVERMORE, KENTUCKY

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I. SUMMARY

In July, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate exposures to aluminum dross dust and ammonia vapors at the Barmet Aluminum Corporation in Livermore, Kentucky.

NIOSH industrial hygienists conducted a site visit on August 11 and 12, 1987, to monitor workers' exposure to ammonia vapors, aluminum dross, and respirable silica (quartz) dust. Seven area samples were collected to measure respirable dust (dross) and respirable silica. The silica content ranged from non-detectable to 3.6%, with a mean of 2.4%. The respirable dust levels ranged from 0.17 milligrams per cubic meter of air (mg/m^3) in the silo loading shed to 82.6 mg/m^3 in the dross mill. The respirable silica concentration for these samples was less than 0.03 mg/m^3 and 1.156 mg/m^3, respectively. Three area samples for total dust ranged from 16.8 to 38.3 mg/m^3 The Occupational Safety and Health Administration (OSHA) requires that the 8-hour permissible exposure limit (PEL) to nuisance dusts not exceed 5 mg/m^3 respirable dust or 15 mg/m^3 total dust. The American Conference of Governmental Industial Hygienists (ACGIH) recommends that exposure to total nuisance particulates not exceed 10 mg/m^3. This value is for total dust containing no asbestos and less than 1% crystalline silica. Since aluminum dross dust contains more than 1% crystalline silica, it should not be considered a simple nuisance dust. Eleven personal samples for respirable dust ranged from 1.14 to 11.3 mg/m^3. The personal samples for respirable silica ranged from non-detectable to 0.086 mg/m^3. The NIOSH Recommended Exposure Limit (REL) for respirable free silica is 0.05 mg/m^3, as averaged over a 10-hour day. The ACGIH TLV for respirable quartz silica is 0.1 mg/m^3.

Ammonia is produced when moisture comes in contact with the dross. The instantaneous grab samples for ammonia collected in the hammer mill ranged from 5 to 38 parts per million (ppm) with a mean value of 25 ppm. The NIOSH REL for ammonia is 50 ppm, as averaged over a 10-hour day, with a 5 minute ceiling level not to exceed 50 ppm.

On October 21 and 22, 1987, a NIOSH medical officer interviewed 12 employees in the dross mill and 12 employees in the rolling mill, using a self-administered questionnaire. Dross mill workers were, on average, four years older and had worked at Barmet two years longer than rolling mill workers. The groups were comparable with respect to smoking history. Current symptoms were no more prevalent among dross mill workers than among rolling mill workers. Without exception, chronic respiratory effects were present among the smokers in both groups and absent in all non-smokers.

Based on the environmental sample results, the investigators concluded that the airborne concentrations of total dust (dross dust), respirable dust, and respirable silica dust, are in excess of either the NIOSH recommended exposure limits or the OSHA permissible exposure limits. Although respiratory symptoms among dross mill workers were not more prevalent than among rolling mill workers, measures should be taken to prevent adverse health effects that may occur as a result of prolonged exposure. Recommendations regarding respiratory protection, medical surveillance, and engineering controls to reduce employees' exposures in the dross mill and the cast house are contained in Section VIII of this report.

KEYWORDS: SIC 3341, aluminum, dross, silica, ammonia, smelting.

II. INTRODUCTION

On July 4, 1987, NIOSH was requested by an employee representative to investigate employees' exposures to aluminum dross dust and ammonia vapors at Barmet Aluminum Corporation in Livermore, Kentucky. The requestor was concerned about the possible health effects from breathing the dust in the dross mill, cast house, and furnace building.

In response to the request, three NIOSH industrial hygienists conducted a site visit to the company on August 11 and 12, 1987. During the visit, the investigators monitored the workers' exposure to the aluminum dross in the form of total dust, respirable dust, and respirable silica (quartz) dust. Ammonia vapors were also monitored. Private interviews were held with eleven of the workers to determine if they had any complaints concerning their work environment or health problems. As a follow-up to these interviews, a NIOSH medical officer conducted a site visit on October 21 and 22, 1987. At that time 24 employees, 12 from the dross mill and 12 from the rolling mill, were interviewed using a questionnaire addressing respiratory symptoms and other health information.

III. BACKGROUND

The company is an aluminum smelting facility and rolling mill that manufactures aluminum coil. The raw materials used in the smelting process are approximately 80% aluminum dross and 20% scrap aluminum metal. Dross is a by-product of the melting process which is skimmed off the molten aluminum surface and cooled. The dross is recycled in the hammer mill by breaking up the hard dross and separating the metal from a rock-mineral material.

The process begins when trucks deliver the dross from primary and secondary aluminum smelters. The hard dross is passed through a series of hammer mills and screens by conveyor belts to separate the metal from the inert rock. During each step the dross is broken into smaller and finer particles to recover the metal. The recovered metal is stored in segregated bins inside the dross mill. Front-end loaders move the metal from these bins to three furnaces in the cast house, while the waste rock is stored in a silo for removal by trucks to a landfill. The plant processes approximately 500,000 tons of dross a day. The front-end loaders feed the dross-metal into the open end of the furnace. Sodium chloride and potash are added to the furnace as fluxing agents. During the survey, two of the three furnaces were in operation. These rotary furnaces are steel jacketed, brick-lined, and open at each end. The furnaces are end-fired by a natural gas burner. As the furnace rotates, molten slag on the surface of the metal spills from the opening into a crucible. Once the slag is cooled, it is recycled again in the dross mill as dross. When the furnace is full of molten aluminum, it is tapped-off from the bottom into a ladle and transported to the rolling mill on a monorail. The molten metal may be cast into ingots or added directly to the reverberatory furnace. The metal is then de-gassed with nitrogen gas and cast into a continuous slab. The slab is annealed, stretched, and leveled until it exits as a large coil.

The workforce in the dross mill and cast house consists of approximately 30 workers. Currently there are three work shifts. The first (700-1500) and third (2300-700) shifts are scheduled for processing the dross and smelting. The second shift (1500-2300) is mainly a maintenance shift. On the day of the environmental evaluation, August 12, there were 11 employees on the first shift in the dross mill, cast house, and silo area. Three utility operators and a crusher operator worked in the dross mill. Three loader drivers moved the dross materials in both the dross mill and the cast house. Three furnace operators worked in the casting area. One silo operator was responsible for loading the trucks with the waste dross material. The dross mill began operation at 9:08 and stopped at 14:30 due to a malfunction. During the five and a half hours of operations the amount of dross material processed was typical for that length of time.

The employee complaints centered on the high levels of dust generated from the dross crushing. At times during the NIOSH survey, the dust was so dense that visibility was greatly reduced. In 1980 and 1981 the Kentucky Department of Labor collected personal respirable dust samples from the dross mill employees. The levels ranged from 3.90 to 43.5 mg/m^3. In addition, ammonia vapors are released from the dross when moisture or high humidity is present. The source of the ammonia may be from the nitrogen gas that is bubbled through the molten metal during primary and secondary smelting. The nitrogen removes other gas dissolved in the metal that act as impurities. The ammonia problem is apparently greatest when the floor of the dross mill is sprayed with water to control the dust in the building. The equipment in the dross mill and the silo loading area has extensive local exhaust ventilation to remove the airborne dust to three bag houses.

IV. EVALUATION DESIGN AND METHODS

NIOSH investigators first visited the plant site on August 11 and 12, 1987, to meet with management and labor representatives, to conduct an evaluation of environmental exposures, and to interview 11 employees in the dross mill and cast house. On October 22 and 23, 1987, a NIOSH medical officer conducted a site visit at the company to interview employees and to administer a questionnaire.

A. Environmental

A bulk sample of dross was submitted, by a labor representative, to NIOSH in June 1987. This sample was analyzed qualitatively for asbestos, silica, fluorides, and other elements. Asbestos was analyzed by polarized light microscope and dispersion staining techniques. Silica analysis consisted of X-ray powder diffraction and X-ray fluorescence spectrometry. This method also detects elements that are heavier than silicon. Fluoride was analyzed by ion selective electrode according to NIOSH Method 7902 (1). Other elements were analyzed by inductively coupled argon plasma, atomic emission spectroscopy (ICP-AES) according to NIOSH Method 7300 (1).

Personal breathing-zone samples for respirable dust and respirable silica dust were collected from 11 employees. A battery powered vacuum pump with a flow rate of 1.7 liters of air per minute (lpm) was used to collect the samples on pre-weighed 37-mm, 5-um pore size, polyvinyl chloride membrane filters placed inside a cassette filter holder. The cassette was preceded by a 10-mm Dorr-Oliver cyclone. After sampling the filters were re-weighed according to NIOSH Method 0600 (1). The silica content of these samples was then determined by X-ray powder diffraction according to NIOSH Method 7500 (1).

Area samples for respirable and silica dust were collected in the silo truck loading shed and in the area known as the "pit". This area, located in the dross mill below the hammer mill, is approximately 20 feet wide, 60 feet long, and 20 feet deep. Access to this pit is by a ladder. Because of the limited access, this area can be classified as a confined space.

Area total dust samples were collected on pre-weighed 37-mm, 5-um pore size, polyvinyl chloride membrane filters. Analysis was performed according to NIOSH Method 0500 (1).

Ammonia vapors were measured with National/Drager colorimetric detector tubes. The grab samples were collect at seven locations in the dross mill at various times.

High volume area airborne samples for respirable dust and respirable silica dust were collected in the dross mill approximately 15 feet from the conveyor belt. The area samples were collected on pre-weighed 37-mm, 5-um pore size, polyvinyl chloride membrane filters preceded by a cyclone. The flow rates were 9.3 and 9.5 lpm. Analysis was also performed according to NIOSH Methods 0600 and 7500.

Temperature and relative humidity were measured during the shift in the dross mill, cast house, and the rolling mill.

B. Medical

The medical investigation consisted of a questionnaire survey which included all 12 available dross mill workers from both shifts, and 12 randomly selected rolling mill workers from the first shift, chosen as a group for comparison.

A self-administered questionnaire was answered by each individual; it addressed current symptoms, past respiratory illnesses and other medical history, smoking history, and occupational history. Since the workers were relatively young and had generally not been at the plant very long, there was little likehood of finding work-related pulmonary function impairment or X-ray changes, so these studies were not undertaken.

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Thershold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Specific Substances and Agents

1. Silica

Crystalline silica, usually referred to as free silica, is defined as silicon dioxide (SiO_2) molecules arranged in a fixed pattern, as opposed to nonperiodic, random molecular arrangement referred to as amorphous silica. The three most common crystalline forms of free silica encountered in industry are quartz, tridymite, and cristobalite, with quartz being by far the most common of these. One of the principal adverse health effect of crystalline silica is the dust-related respiratory disease, silicosis. Silicosis is a form of diffuse interstitial pulmonary fibrosis resulting from the deposition of respirable crystalline silica in the lungs. Conditions of the exposure may affect both the occurrence and severity of silicosis. Although it usually occurs after 15 or more years of exposure, some forms with latent periods of only a few years are well recognized and are associated with intense exposures to respirable dust high in free silica (2). Early, simple silicosis usually produces no symptoms. However, both acute and complicated silicosis (progressive massive fibrosis, PMF) are associated with shortness of breath, intolerance for exercise, and a marked reduction in measured pulmonary function. Diagnosis is most often based on a history of occupational exposure to free silica and the characteristic appearance of a chest radiograph. Respiratory failure and premature death may occur in advanced forms of the disease. Individuals with silicosis are also at increased risk of contracting tuberculosis. No specific treatment is available, and the disease may progress even after a worker is no longer exposed to silica. There is also evidence suggesting that silica may be carcinogenic, however, studies to date are inconclusive (3).

NIOSH, in its recommendations for a free silica standard, has proposed that exposures to all forms of free silica be controlled so that no worker is exposed to respirable airborne concentrations greater than 0.05 mg/m^3, averaged over a 10-hour working day, 40-hour work week (4). This recommendation was designed to protect workers from silicosis. Exposures to free silica greater than one-half the recommended standard, or "action level", should initiate adherence to the environmental, medical, labeling, recordkeeping, and worker protection guidelines contained in the NIOSH criteria document, "Occupational Exposure to Crystalline Silica" (5). The current Federal, or Occupational Safety and Health Administration's (OSHA) standard (6) for respirable free silica exposure is an 8-hour time-weighed average based upon the 1968 American Conference of Governmental Industrial Hygienists (ACGIH) TLV formula (7) of 10 mg/m^3 divided by the sum of the percent SiO2 and 2 [10 mg/m^3/%SiO2+2] for respirable quartz. As can be seen from the calculation, the OSHA regulation is based on the percentage of free silica contained in the respirable particulate exposure, whereas the NIOSH recommended standard applies directly to the airborne concentrations of respirable free silica. ACGIH now has a TLV of 0.1 mg/m^3 for respirable quartz (8).

2. <u>Nuisance Dusts</u>

Airborne nuisance dusts are supposedly dusts which have little adverse effects on the lungs and do not produce significant organic disease or toxic effect when exposures are kept under resonable control (8). For nuisance dusts OSHA requires that the 8-hour permissible exposure limit (PEL) not exceed 5 mg/m^3 respirable dust or 15 mg/m^3 total dust (6). The ACGIH recommends that exposure to total nuisance particulates not exceed 10 mg/m^3. This value is for total dust containing no asbestos and less than 1% crystalline silica. Since aluminum dross dust is a source of ammonia and contains more than 1% crystalline silica, it should not be considered a simple nuisance dust.

3. Aluminum and Aluminum Oxide

Cases of pulmonary fibrosis sometimes called "aluminum lung" (9), as well as asthma have been reported in workers involved in various manufacturing processes (10). The pulmonary fibrosis attributed to aluminum is associated with two different inhalant materials: fumes derived from the smelting of bauxite (an aluminum oxide) resulting in "Shaver's disease", (respirable crystaline silica possibly plays the central role in precipitating the disease) (11,12); and inhalation of aluminum dust (9). The majority of pulmonary aluminosis cases resulted from exposures to respirable aluminum pyrotechnic flakes that were lubricate with a non-polar aliphatic oil. Ordinarily, stearic acid, which chemically combines with aluminum to form aluminum stearate, was used as a lubricant to retard surface oxidation during milling of such flake. The aliphatic oils simply physically coat the flakes to prevent elemental aluminum from oxidation. Removal of the surface oil from the metal flakes in the lungs permits oxidation of the metal in a vigorous exothermic reaction, resulting in tissue damage (12). Although the harmful effects of using non-polar oils to coat aluminum particultes has been identified, the role of aluminum dust or fumes in the pathogenesis of lung fibrosis is uncertain. It can be concluded that aluminum may sometimes be responsible for causing pulmonary fibrosis, but the exact occupational circumstances and conditions are not yet completely clear. The ACGIH recommends that exposure to aluminum metal and oxide not exceed 10 mg/m^3 while exposure to very fine aluminum powder and and fumes not exceed 5 mg/m^3 (8).

4. Ammonia

Ammonia is a colorless, water-soluble gas with a characteristic pungent odor. Ammonia reacts readily with water to form an extremely alkaline solution, producing tissue burns of the eyes, skin, or respiratory tract. Mild to moderate exposure to ammonia gas can produce headache, salivation, burning of the throat, loss of the sense of smell, nausea, vomiting, and chest pain. The health effects from these mild to moderate ammonia exposures are largely reversible and do not cause permanent damage. Lower exposures may result in coughing, while high exposures may cause lung problems including bronchospasms and pulmonary edema (accumulation of fluid in the lungs), with permanent lung damage and death (13-16). Blood-stained sputum can be an indicator of high ammonia exposures.

Ammonia has an odor threshold of about 0.03 ppm, which is well below toxic levels (17). Most workers will experience irritation at exposure levels of about 25 ppm or above. The OSHA PEL for ammonia is 50 ppm as a TWA measured over the entire workshift. NIOSH recommends a five-minute ceiling exposure limit of 50 ppm for ammonia (4). The ACGIH TLV exposure recommendation for ammonia is 25 ppm as a 8-hour TWA and a short term exposure limit TLV of 35 ppm as a 15-minute TWA (7). Ammonia concentrations of approximately 500 ppm or greater are considered to be immediately dangerous to life and health (IDLH) (16).

VI. RESULTS AND DISCUSSION

A. Environmental

1. Bulk Sample of Dross

The bulk sample of dross, collected by a labor representative, contained approximately 13.2% (by weight) sodium, 11.5% aluminum, 1.79% magnesium, 1.13% iron, and less than 1% of each of several other metals listed on Table 1. Several metals, including arsenic, beryllium, cadmium, chromium, lead, and nickel, if present, were in concentrations of less than 0.01%. Qualitative XRF results indicated the presence of chlorine in large amounts and traces of iron and titanium. No elements heavier than atomic number 26 (iron) were detected. Quartz (silica) concentration was 8 percent (±30%) by weight. Fluoride concentration was 47 ug/g. There was no detectable asbestos in the sample.

In 1980 and 1981 the Kentucky Department of Labor collected surface wipe samples in the plant. Detectable levels of copper, magnesium, manganese, iron, sulfides, chlorides and fluorides were present in the samples. This demonstrates that the composition of the dross is not consistent but varies between batches and suppliers.

2. Area Airborne Samples for Respirable Dross

Seven area samples were collected to measure respirable dust (dross) and respirable silica dust. The results are presented in Table 2. The silica content of these samples ranged from non-detectable to 3.6%, with a mean of 2.4%. In the center of the dross mill the respirable dust levels ranged from 4.22 mg/m^3 in the morning to 82.6 mg/m^3 in the late afternoon. The respirable silica concentration for these samples was 0.138 mg/m^3 and 1.16 mg/m^3 respectively. A sample collected in the pit during the afternoon contained 67.4 mg/m^3 respirable dust and 0.602 mg/m^3 silica. Visibility in this area, adjacent to the hammer mill, was reduced to a few feet. A sample collected in the loading shed measured 0.17 mg/m^3 respirable dust with no detectable silica.

3. Area Airborne Samples for Total Dust

In addition to the respirable dust samples, three area samples for total dust were collected. Levels ranged from 16.8 to 38.3 mg/m^3, (Table 3).

4. Personal Samples for Respirable Dust and Respirable Silica

The personal samples had respirable dust concentrations ranging from 1.14 to 11.3 mg/m^3 (Table 4). The personal samples for respirable silica ranged from non-detectable to 0.086 mg/m^3. The sample results in Table 4 are also calculated as an 8-hour TWA. The silica content of the respirable dust samples varied greatly between samples. An example is the silo operator who had an exposure to respirable dust of 11.3 mg/m^3 and a non-detectable exposure to silica. The three furnace operators who for the most part remained in the cast house had exposures to respirable dust of 2.42, 1.14, and 6.32 mg/m^3. Their exposure to respirable silica was non-detectable. The utility operators, the loader drivers, and the crusher operator had exposures to respirable dust ranging from 1.49 to 8.33 mg/m^3. Their exposures to respirable silica ranged from non-detectable to 0.086 mg/m^3.

5. Area Airborne Ammonia Samples

The instantaneous grab samples for ammonia collected in the dross mill had concentrations ranging from 5 to 38 ppm with a mean value of 25 ppm (Table 5). The lowest measurement was collected on the bucket elevator 30 feet from the floor. A portion of the roof above this collection site was missing and accounts for the low ammonia level. Ammonia levels were mostly unchanged throughout the shift and did not increase after the floor was sprayed with water to control the dust. In the pit where the dust levels were high, the ammonia concentrations were 27 and 30 ppm. The detector tubes used to monitor the airborne ammonia measure the ammonia vapors. It is not known how the dross dust trapped inside the tube would affect the accuracy of the detector tubes. The ammonia odor was very noticeable to the investigators in both the hammer mill and the furnace room.

6. Temperature and Humidity

The air temperature at noon in all three departments; dross mill, cast house, and rolling mill was approximately 100°Fahrenheit (Table 6). The relative humidity ranged from 23 to 55 percent. Four of the temperature and relative humidity values in Table 6 are estimates because the psychrometer used during the survey could record temperatures only up to 100°F.

B. Medical

All 24 workers in this survey were male, from 19 to 39 (average = 28) years of age. Their length of time employed at Barmet ranged from 2 months to 9 years (average = 4 years).

The group's previous occupational exposure history was diverse, with prior job exposure to wood dust being the most frequently reported (6 workers). None of the workers reported previous work in a coal mine or quarry, or in any job involving exposure to silica dust.

Dross mill workers were slightly older and had worked at the company longer than rolling mill workers (Table 7). The smoking history among dross mill workers was comparable to that of rolling mill workers. The prevalences of various current symptoms among dross mill workers were no higher than those among rolling mill workers. A seemingly high prevalence of chronic bronchitis and mild, occasional wheezing was present among the members of both groups, but all of these individuals were smokers. There were fewer past respiratory illnesses reported by dross mill workers. None of the workers related the onset of their symptoms or illnesses to conditions in their work environment.

VII. CONCLUSIONS

Based upon the environmental sampling results, it is concluded that the airborne concentrations of total dust, respirable dust, and respirable silica dust, are in excess of the NIOSH Recommended Exposure Limits. In addition, there are the potentially harmful effects from the ammonia vapors being released from the dross dust. This could happen when the dust is inhaled and comes in contact with the moisture of the respiratory tract. Although the exposed employees currently do not have any apparent health problems, the continued exposure to dross dust may, over many years, have a detrimental effect on their health.

VIII. RECOMMENDATIONS

Engineering Control Measures and Process Modification

1. Airborne concentrations of the silica containing dross dust should be further reduced. Improvements need to be made on the dross handling system to minimize dust exposures. This will require a major effort by an engineering consulting firm to upgrade the local ventilation system to the level necessary to reduce workers' exposures to silica. After this is done, an industrial hygiene evaluation of the system should be conducted. Periodic evaluations of the local exhaust ventilation system's performance characteristics should be made.

2. Wetting the floor to suppress dust generation is effective but may lead to increased levels of ammonia vapors. In addition, maintenance workers will then have to shovel the hardened dross to remove it from the floor.

3. A possible means to control airborne dust is to spray the dust with a coating of stearic acid or other polar lubricants. This technique is used in the production of aluminum pyropowder and flakes to decrease pyrophoric hypersensitivity of the particulates which in turn permits the safe handling of the flakes (12). It is important not to use a non-polar mineral oil in controlling dust. The use of mineral oils could lead to pulmonary aluminosis in workers as reported in the literature.

4. Overhead air supply islands (an air cleaning device that is suspended over the operator and provides a flow of filtered air over the work station) are an effective means of controlling employee exposures to metal fumes during the tapping of a rotary furnace (18). This method of supplying clean air to workers in fixed locations may have application for the silo operator and the crusher operator. Workroom air is drawn into the system and passed through automatically self cleaning filters. The air can then pass through a heating or cooling chamber. The resulting filtered air flows down over the operator at an average velocity of 375 feet per minute, which restricts mill air from entering the clean air core. Systems of this kind are commercially available.

5. The cabs of the front-end loaders should be enclosed and air-conditioned with an air purifying system. The filters must be checked frequently and replaced as needed.

6. NIOSH considers open-topped spaces such as pits to be confined spaces. Access to pits requires the use of ladders, hoists, or other devices which make escape from such areas very difficult in

emergency situations. Poor natural ventilation may result in the build up of toxic gases, vapors, or particulates. Oxygen levels may also be deficient within the pit. The pit in the dross mill does have local ventilation to remove dross dust; however, the dust levels in the pit during operations are very high. This creates a potential hazard to workers who enter this area. Workers should not enter this area during operation of the hammer mill. If it is necessary to enter the pit during operations, then a NIOSH approved supplied air respirator should be worn. The local ventilation in the pit should remain on whenever workers enter this area.

7. Whenever possible the dross material should be transferred by enclosed conveyor belts with exhaust ventilation rather that using front-end loaders. Two other types of material handling equipment used in the aluminum production industry are pneumatic unloaders and multipurpose cranes (19). Both transport ores, dross, or coke with vacuum pickup nozzles that can move materials from barges to the furnaces.

8. The unloading and transfer of dross materials to and from the storage bays results in airborne dust. This dust could be reduced by installing clear plastic curtains to enclosed this area.

9. Efforts to control noise throughout the plant by engineering controls should continue. In areas where the engineering controls are not adequate, such as during the rebuilding of the furnaces, workers should wear hearing protection.

Education and Work Practices

1. Employees should change work clothes daily and shower after each shift.

2. Safety meetings for employees should be held on a regular bases.

3. Worker education is a vital aspect of a good exposure control program. Employees should be informed of the hazards associated with silica exposure and the correct usage and maintenance of respirators.

Personal Protective Equipment

1. Respirator use by the workers will greatly reduce their exposure to the dross dust. Because of the heat in the plant, most types of respirators will be very uncomfortable to the wearer. A comfortable and effective type of respirator is the powered air purifying helmet. This respirator provides a curtain of filtered

air in the wearer's breathing zone and appears to reduce the dust exposure experienced by the operator. A preferred respirator program is one where one person is assigned to clean, sanitize, and fit-test the respirators. It should be noted that the use of respirators by workers is encouraged by NIOSH when effective engineering controls are not feasible, or while the controls are being instituted.

2. Wearing lightweight, bright yellow or orange vests by the workers in the hammer mill and furnace area will make the workers more visible to the loader-drivers, thereby avoiding accidents.

Programs and Exposure Assessments

1. A respiratory protection program should be established, consistent with the guidelines found in NIOSH publication no. 87-116, "NIOSH Guide to Industrial Respiratory Protection,"(20) and the requirements of the General Industry Occupational Safety and Health Standards (29 CFR 1910.134). Copies of NIOSH publication no. 87-116 are available through Publications Dissemination, DSDTT, NIOSH, 4676 Columbia Parkway, Cincinnati, Ohio 45226; telephone number (513) 841-4287.

2. A heat stress evaluation should be conducted for employees in all areas of the plant. Information on a formal heat stress program can be found in the NIOSH publication, "Occupational Exposure to Hot Environments, Criteria for a Recommended Standard" (21).

Medical

1. All employees exposed to silica should have preplacement and periodic medical evaluations. Included in these should be a medical and occupational history, physical examination, pulmonary function tests, and a chest X-ray.

    a. The X-rays can be taken infrequently at first (at 5-year intervals, for example) unless other medical finding suggest a diagnostic X-ray should be done sooner. After 10 years of exposure, X-rays should be done annually. The X-rays should be read according to the International Labour Organisation system. Physcians certified in X-ray interpretation according to this system are designated as "B" readers.

    b. Annual pulmonary function testing should be performed using equipment and procedures conforming to the American Thoracic Society's criteria for screening spirometry.

2. An employee with significant respiratory symptoms, physical findings, pulmonary function test abnormalities, or X-ray signs of pneumoconiosis should be evaluated by a physician (preferably a pulmonary or occupational medicine specialist) to determine whether it is advisable for the the employee to be removed from further exposure to silica.

3. The fibrosis that occurs after prolonged exposure to silica may continue for several years after removal from exposure. However, at the present time, factors determining progression remain unclear. Therefore, the medical surveillance program should also be available to former employees and to current employees no longer exposed to silica.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Barmet Aluminum Corporation

2. International Molders and Allied Workers Union, Local 55

3. International Molders and Allied Workers Union, Health and Safety Department, Cincinnati, Ohio

4. NIOSH, Cincinnati Region

5. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

HETA 87-321
Barmet Aluminum Corporation
Livermore, Kentucky

July 31, 1987

Sample of Dross

Metal	Percent by Weight
Aluminum	11.50
Antimony	<0.01
Arsenic	<0.01
Barium	0.01
Beryllium	<0.01
Cadmium	<0.01
Calcium	0.79
Chromium	<0.01
Copper	0.01
Iron	1.13
Lanthanum	<0.01
Lead	<0.01
Lithium	<0.01
Magnesium	1.79
Manganese	0.07
Molybdenum	0.02
Nickel	<0.01
Phosphorus	0.02
Platinum	<0.01
Selenium	<0.01
Silver	<0.01
Sodium	13.20
Strontium	<0.01
Tellurium	<0.01
Thallium	<0.01
Titanium	0.09
Vanadium	<0.01
Yttrium	<0.01
Zinc	<0.01
Zirconium	<0.01

The limit of quantitation was 0.01%.

TABLE 2

HETA 87-321

Barmet Aluminum Corporation
Livermore, Kentucky

August 12, 1987

Area Airborne Samples for
Respirable Dust, and Respirable Silica Dust

Location	Time Sampled	Sample Volume in Liters	mg/m^3 Respirable Dust	Respirable Silica
Silo, loading shed	1035-1507	466	0.17	ND
Pit area	1325-1415	83	67.35	0.602
Dross mill	820-1029	1225	4.22	0.138
Dross mill	1030-1130	558	11.80	0.179
Dross mill	1030-1130	570	13.21	0.474
Dross mill	1405-1434	270	82.59	1.156
Dross mill	1405-1434	275	30.47	1.091

ND = non-detected (less than 0.015 mg/sample)

TABLE 3

HETA 87-321

Barmet Aluminum Corporation
Livermore, Kentucky

August 12, 1987

Area Airborne Samples for Total Dust

Location	Time Sampled	Sample Volume in Liters	mg/m^3
9798	824-1505	804	16.8
9802	1042-1502	522	38.3
9797	807-1512	844	22.7

The flow rate for the sampling equipment was 2.0 liters per minute.

TABLE 4

HETA 87-321
Barmet Aluminum Corporation
Livermore, Kentucky

August 12, 1987

Personal Airborne Samples for
Respirable Dust and Respirable Silica Dust

		mg/m^3			
		Actual		8-hour TWA	
Job Title	Time Minutes	Respirable Dust	Respirable Silica	Respirable Dust	Respirable Silica
Furnace Operator 1	467	2.42	ND	2.35	ND
Furnace Operator 2	468	1.14	ND	1.12	ND
Furnace Operator 3	116	6.32	ND	0.53	ND
Utility Operator 1	409	6.06	0.086	5.16	0.074
Utility Operator 2	410	5.19	0.072	4.44	0.064
Utility Operator 3	418	3.61	0.042	3.15	0.037
Loader Driver 1	421	4.04	0.042	3.54	0.037
Loader Driver 2	423	8.33	0.070	7.34	0.061
Crusher Operator	446	2.76	0.026	2.56	0.025
Loader Driver 3	446	1.49	ND	1.38	ND
Silo Operator	442	11.3	ND	10.4	ND

ND = non-detectable (less than 0.015 mg/sample)
TWA = time-weighted average
The flow rate for the sampling equipment was 1.7 liters per minute.

TABLE 5

HETA 87-321

Barmet Aluminum Corporation
Livermore, Kentucky

August 12, 1987

Area Airborne Ammonia Samples

Location	Time	Ammonia in ppm
Center of dross mill before wetting the floor	840	35
Adjacent to impactor after wetting the floor	850	20
In the pit, below the hammer mill	900	30
Adjacent to hammer mill	1230	38
Adjacent to dross pile	1235	22
In the pit	1415	27
Above the pit	1420	30
J & H Bucket Elevator 30 feet above floor	1425	5
Walkway 18 feet above floor below the J & H Bucket Elev	1430	20

Limit of detection = 5 ppm

TABLE 6

HETA 87-321

Barmet Aluminum Corporation
Livermore, Kentucky

August 12, 1987

Temperature and Relative Humidity

Location	Time	Temperature in Fahrenheit	Relative Humidity in %
Dross Mill			
Near hammer mill	950	89	55
Near hammer mill	1310	100	23
Inside cab of front-end loader	1020	96	42
Inside cab of front-end loader	1330	>100	34*
Cast House			
Center of building	1000	98	38
Rolling Mill			
Casting area	1247	>100	39*
Casting area	1250	>100	39*
Annealing line	1255	>100	39*

* = Percent relative humidity for readings with a temperature greater than 100°Fahrenheit are estimates.

Table 7

HETA 87-321

Barmet Aluminum Corporation
Livermore, Kentucky

Occupational and Medical History Of Workers

	DROSS MILL WORKERS	ROLLING MILL WORKERS
Age (yrs.)	Range = 19-39 Mean = 30	Range = 19-36 Mean 26.3
Time at Barmet	Range = 2 mos.- 9 yrs. Mean = 5 yrs.	Range = 3 mos. - 5 yrs Mean = 3 yrs.
Time on current job	Range = 2 mos. - 9 yrs. Mean = 4.3 yrs.	Range = 3 mos. - 5 yrs. Mean = 3 yrs.
Smoking history	Range = 0 - 23 pack-yrs. Mean = 8 pack-yrs. % Current smokers 67 % Former smokers 8 % Never smoked 25	Range = 0 - 23 pack-yrs. Mean = 7.3 pack-yrs. % Current smokers 67 % Former smokers 0 % Never smoked 33
Current symptoms	1. headache - 2 (16.6%) 2. blurred vision - 0 3. eye irritation - 3 (25%) 4. tearing of eyes 2 (16.6%) 5. runny nose - 3 (25%) 6. stopped up nose 4 (33%) 7. sore throat - 1 (8%) 8. hoarness - 0	1. headache - 3 (25%) 2. blurred vision - 0 3. eye irritation - 2 (16.6%) 4. tearing of eyes - 2 (16.6%) 5. runny nose - 7 (58%) 6. stopped up nose - 6 (50%) 7. sore throat - 2 (16.6%) 8. hoarness - 2 (16.6%)
Respiratory effects	1. dry cough - 0 2. chronic bronchitis 5 (41.6%) 3. wheezing - 5 (41.6%) 4. breathlessness - 0 5. chest colds/ chest illness - 0	1. dry cough - 0 2. chronic bronchitis 5 (41.6%) 3. wheezing - 4 (41.6%) 4. breathlessness - 0 5. chest colds/ chest illness - 0
Past illnesses	1. acute bronchitis - 0 2. pneumonia - 0 3. hay fever - 1 4. chronic bronchitis - 0 5. emphysema - 0 6. asthma - 0	1. acute bronchitis - 1 2. pneumonia - 2 3. hay fever - 1 4. chronic bronchitis - 0 5. emphysema - 0 6. asthma - 1